MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2021/2022

ERE1236 – ANALOG ELECTRONICS

(All sections / Groups)

7 OCT 2022
9:00 AM – 11:00 AM
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 8 pages (including the cover page) with 4 Questions only.

2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

a) State **SEVEN** characteristics found on an IDEAL op-amp. [7 marks]

b) Calculate the following for the circuit shown in Figure Q1 (b):

(i) Name the TYPE of the amplifier. [1 mark]

(ii) The non-inverting voltage, V_+. [2 marks]

(iii) The inverting voltage, V_-. [1 mark]

(iv) The current flowing through the 1.5 kΩ resistor. [2 marks]

(v) The current flowing into the non-inverting input, V_+. [1 mark]

(vi) The current flowing through the 2 kΩ resistor. [1 mark]

(vii) The output voltage, V_A. [2 marks]

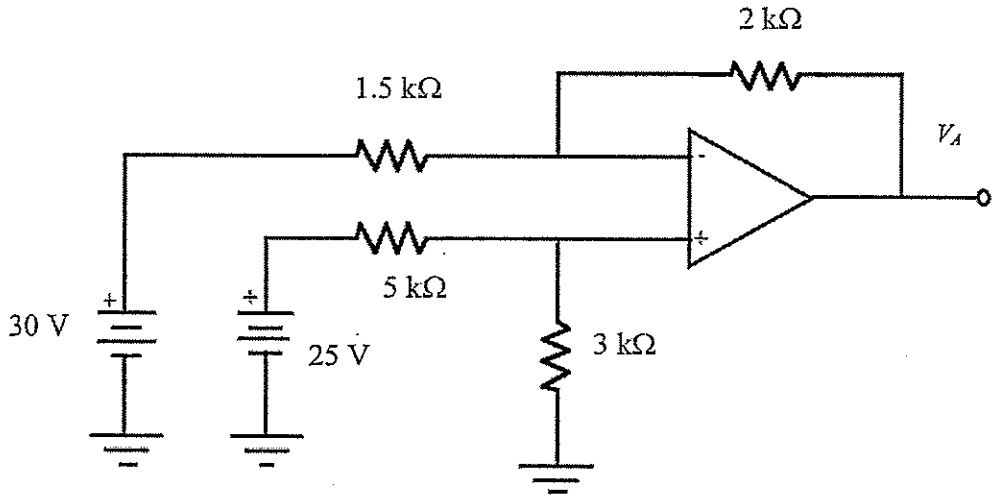

Figure Q1 (b)

c) Figure Q1 (c) shows the input voltage waveform of an op-amp amplifier circuit that has **TWO** inputs. Sketch the output voltage waveform with respect to time if the op-amp is configured to operate as;

(i) an inverting amplifier with a gain of 1. [4 marks]

(ii) a non-inverting amplifier with a gain of 2. [4 marks]

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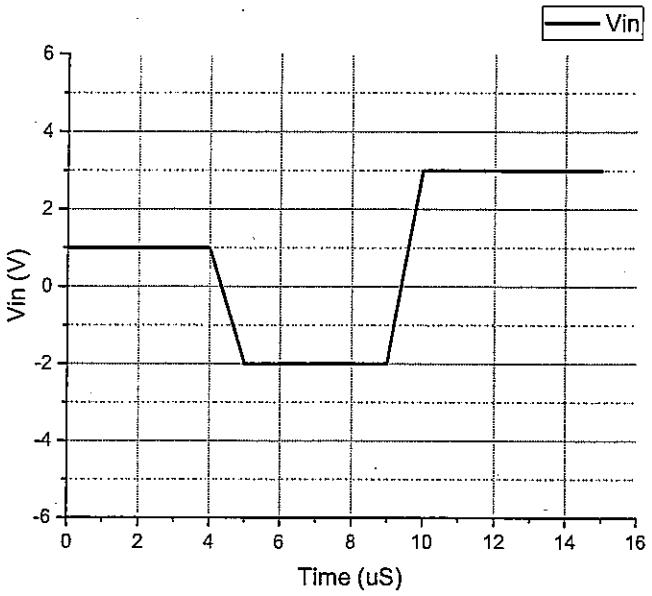

Figure Q1 (c)

Question 2

a) A practical op-amp has the common mode rejection ratio, *CMRR* of 90 dB and the open-loop gain, *AOL* of 1×10^5. The voltage input to the inverting and the non-inverting terminal are 1.05 mV and 0.95 mV respectively. Calculate the following;

(i) the differential voltage, V_d. [2 marks]

(ii) the common-mode voltage, V_c. [2 marks]

(iii) the magnitude of the common-mode gain, A_c. [5 marks]

(iv) the output voltage, V_o range. [5 marks]

b) Figure Q2 (b)(i) shows a non-inverting op-amp that has a slew rate of 1 V/μs. The resistance values given are $R_i = 20\ k\Omega$ and $R_f = 80\ k\Omega$. Note that, the op-amp is biased at ± 5 V.

(i) Calculate the output voltage, V_o. [2 marks]

(ii) Sketch the output voltage versus time for the input shown in Figure Q2(b)(ii). [4 marks]

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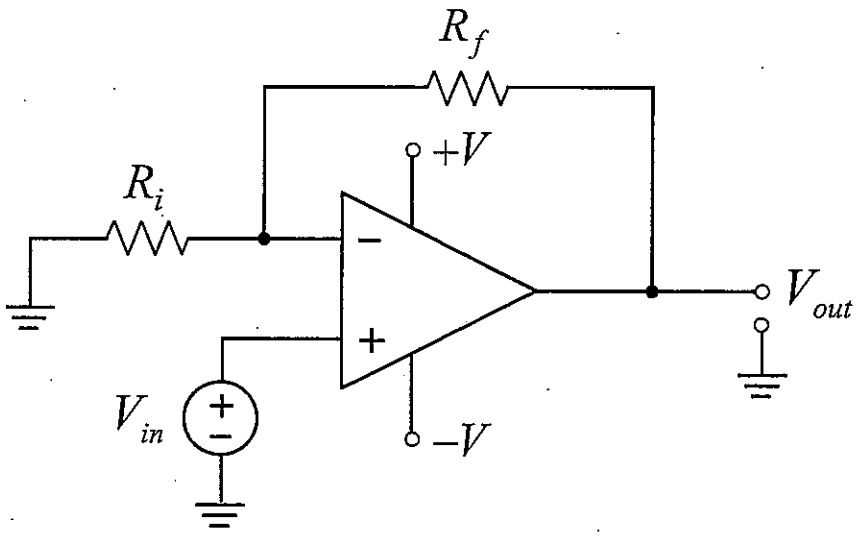

Figure Q2 (b) (i)

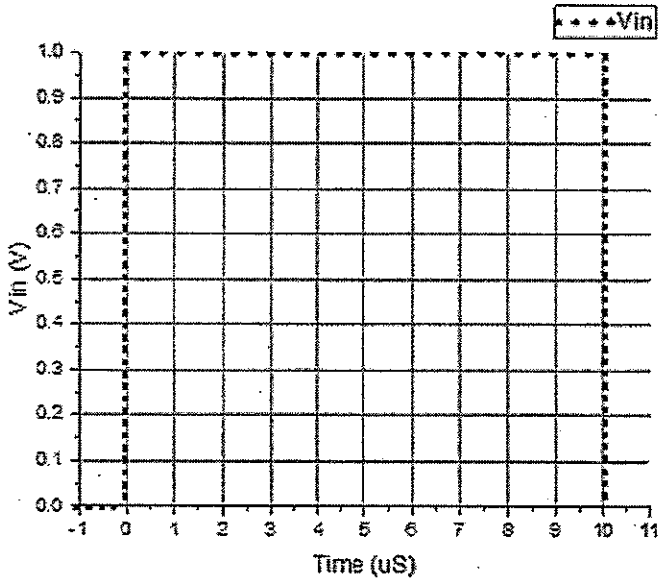

Figure Q2 (b) (ii)

c) A non-inverting amplifier is configured with a feedback resistor, R_f of 220 kΩ and the input resistor, R_i of 33 kΩ. Given the unity gain bandwidth of the op-amp is 1 MHz, calculate the close loop bandwidth. [5 marks]

Continued .....

Question 3

a) Figure Q3 (a) shown a series feedback voltage regulator using an op-amp as the error detector. Given $V_S = 20V$, $R_1 = 35\ k\Omega$, $R_2 = 90\ k\Omega$, h_{FE} of the transistors is 150 and V_{BE} of the transistor is 0.7 V. At steady state, determine the following:

(i) Given the regulated output voltage, $V_o = 10V$, determine V_Z. [3 marks]

(ii) If Zener operating current, $I_z = 12mA$, determine R value. [3 marks]

(iii) Determine the total I_{C1}, if $R_L = 1k\ \Omega$. Assume $I_{C1} = I_{E1}$. Then determine I_{B1}. [3 marks]

(iv) Find the maximum power dissipation P_D for $Q1$, if $R_L = 500\ \Omega$. [5 marks]

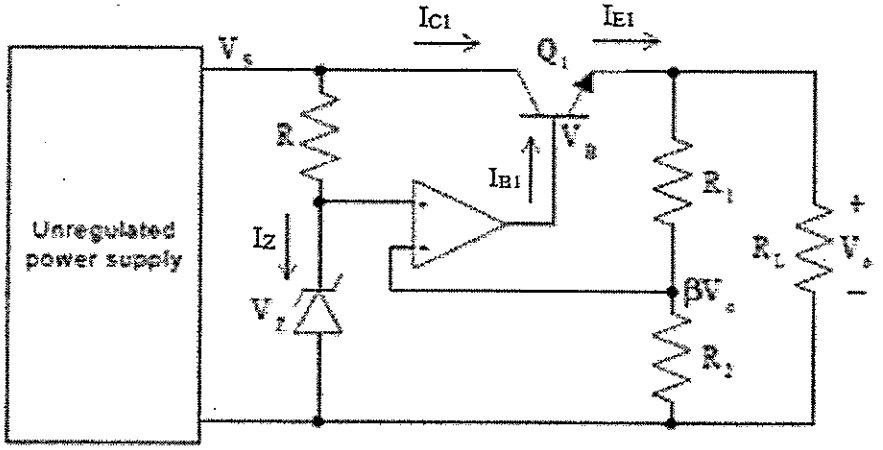

Figure Q3 (a)

b) A phase-shift oscillator circuit is shown in Figure Q3(b), where its feedback voltage gain, β is given as:

$$\beta = \frac{R^3}{R^3 - 5R\left(\frac{1}{\omega C}\right)^2 + j\left[\left(\frac{1}{\omega C}\right)^3 - \frac{6R^2}{\omega C}\right]}$$

Assume the op-amp is ideal.

(i) From the Barkhausen Criterion, derive the formula for oscillation frequency, f_o. [3 marks]

(ii) Determine β and the required amplifier gain, A for oscillation. [3 marks]

Continued .....

(iii) Determine the value of R and C for the circuit with oscillation frequency, f_o = 500 Hz, and $R_F = 300\ \text{k}\Omega$. The voltage gain magnitude of the amplifier should be 3% higher than its minimum value for oscillation.

[5 marks]

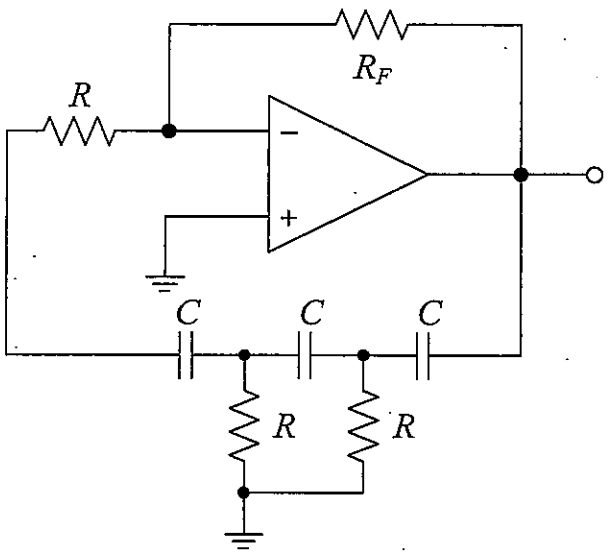

Figure Q3 (b)

Question 4

a) Figure Q4 (a) shows a first-order low pass active filter. **State** and **explain TWO** components in the schematic that can be interchanged to convert into a first-order high pass active filter. [4 marks]

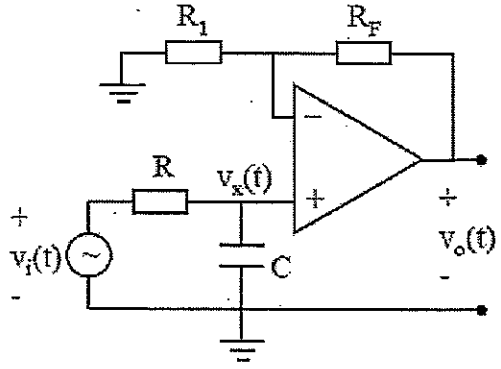

Figure Q4 (a)

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b) The generalized equation based on the Butterworth 2nd order voltage transfer function is $H(s) = K\dfrac{k_2 s^2 + k_1\left(\dfrac{\omega_o}{Q}\right)s + k_0\omega_0^2}{s^2 + \left(\dfrac{\omega_o}{Q}\right)s + \omega_0^2}$, where ω_0 is the undamped resonant frequency, Q is the quality factor, K is the DC voltage gain of the amplifier while k_2, k_1 and k_0 are the constants which determine the type of the filter. Given the voltage transfer function of a filter is as follows;

$$H(s) = K\frac{\left(\dfrac{2500000}{s}\right)}{s + 250 + \left(\dfrac{500000}{s}\right)}.$$

(i) Determine the type of the filter. [3 marks]

(ii) Calculate the values of ω_0, Q and K. [6 marks]

c) State the numerator constant k_0, k_1 and k_2 associated with the following types of filter

(i) Low pass filter. [3 marks]

(ii) High pass filter. [3 marks]

d) Figure Q4 (d) (i) shows a Schmitt trigger circuit. Given that the circuit output voltage swings between + V_{SAT} of +15 V –V_{SAT} of -15 V.

(i) Determine the upper threshold point, V_{UTP} and lower threshold point, V_{LTP} if R_1 and R_2 are 5 kΩ each. [4 marks]

(ii) Sketch the output voltage waveform for the given input voltage waveform in Figure Q4 (d) (ii) with necessary labels. [2 marks]

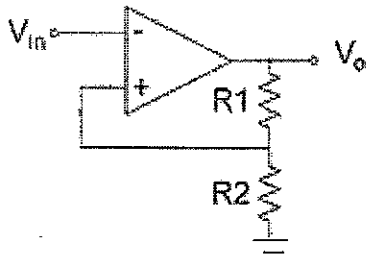

Figure Q4(d)(i)

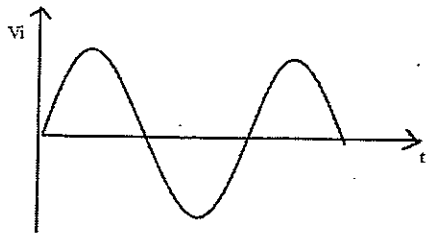

Figure Q4(d)(ii)

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Formulae

$$A_v = A_{ol} = \frac{V_{out}}{V_{in}}$$

$$A_v = A_{cl} = -\frac{R_f}{R_i}$$

Inverting amplifier, $A_{cl} = \frac{V_o}{V_i} = -\frac{R_F}{R_1}$

Non-inverting amplifier, $A_{cl} = \frac{V_o}{V_i} = \left(\frac{R_F}{R_1} + 1\right)$

$$v_d = v_1 - v_2$$

$$v_c = \frac{1}{2}(v_1 + v_2)$$

$$V_o(t) = A_d v_d(t)$$

$$V_o(t) = A_d v_d(t) + A_c v_c(t)$$

$$v_1(t) = v_c(t) + \frac{1}{2} v_d(t)$$

$$v_2(t) = v_c(t) - \frac{1}{2} v_d(t)$$

$$CMRR = \left|\frac{A_d}{A_c}\right|$$

$$CMRR = 20\log_{10}\left|\frac{A_d}{A_c}\right| \text{ dB}$$

$$BW = f_H - f_L$$

$$Q = \frac{f_o}{BW}$$

$$f_o = \sqrt{f_H f_L}$$

$$\omega_o = \frac{1}{RC}$$

$$f_o = \frac{1}{2\pi RC}$$

$$K = 1 + \frac{R_f}{R_i}$$

$$(BW_{cl})(A_{cl}) = \text{unity gain BW}$$

End of paper.